Quantum Field Treatment of DCC Dynamics*

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In the present paper we have sketched how the non-uniform and rapidly evolving scenarios of interest in connection with disoriented chiral condensates may be addressed with real-time non-equilibrium quantum-field theory within the mean-field approximation, in which the interactions are encoded into an effective mass function,

$$\hat{\mathcal{H}}(x) = \frac{1}{2}[\hat{p}(x)^2 + (\nabla\hat{q}(x))^2 + \mu^2(x,t)\hat{q}(x)^2] \ ,$$

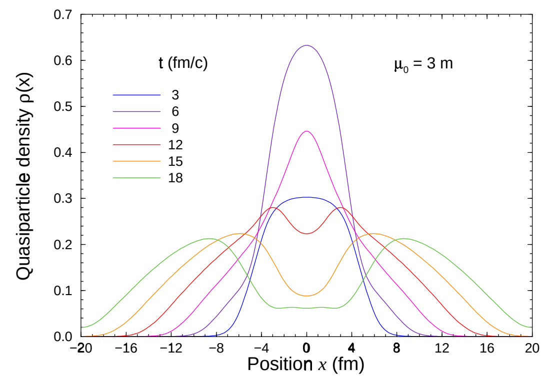
where $\hat{q}(x)$ is the field operator and $\hat{p}(x)$ is its time derivative. In order to bring the problem onto a canonical form, each pair of free traveling waves $|\pm k\rangle$ is replaced by a corresponding pair of standing waves $|\pm\kappa\rangle$

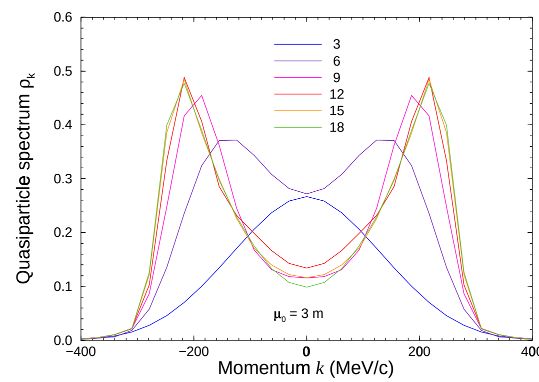
For an arbitrary form of the mass function, the strategy is to first obtain the time evolution operator, which depends only on $\mu^2(x,t)$, and then evaluate the observables resulting from any particular initial quantum state $|t_{\rm i}\rangle$. This makes it economical to perform averages over ensembles of initial states having similar mass functions.

When the eigenvalues of the mass matrix are positive, $\Omega_K^2 > 0$, it is particularly instructive to consider quasiparticle excitations defined relative to the adiabatic eigenbasis. But it should be noted that even if the system enters the classically forbidden region where the quasiparticles cannot be defined, the dynamical propagation of the system works without modification.

A first application of the developed treatment has been made to a system with a non-trivial mass function depending on both time and space, of a form that emulates the mass functions that typically result from dynamical simulations with the semi-classical linear σ model. In addition to demonstrating the practicality of the approach, the example serves to illustrate the quantitative importance of including the quantum fluctuations in the dynamical treatment.

The approach assumes that the effective mass function is given. For the time being, an approximate form of the mass function for a given scenario can be obtained on the basis of semiclassical simulations. Though not fully satisfactory, this approach may actually be reasonably accurate, since the quantum treatment, while having a large effect on specific signals, is expected to have a relatively small overall effect on the effective mass.





The computational challenge posed by the treatment is not prohibitively larger than that met at the classical level, since it merely requires (repeated) solution of the same field equation. The treatment may thus be applied to scenarios similar to those addressed at the classical level. This presents an obvious practical task which should yield more quantitative information on the observable signals of the expected chiral dynamics.

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